Atmospheric Radiation Measurement Program

Facilities Newsletter – June 1999

What's New

The Mesoscale Convective Systems (MCSs) Campaign is underway at the SGP CART site and will continue through September 1999. This field study is investigating the small-scale physics of precipitation and the convective dynamics of MCSs in the middle latitudes.

An MCS is defined as a precipitation system that is 10–300 miles wide and contains deep convection at some time in its life span. MCSs occur in the midlatitudes of the United States and can include large, isolated thunderstorms, squall lines, and mesoscale convective complexes.

Large, isolated thunderstorms formed by convective cells are called air-mass thunderstorms. Formed in a warm, humid air mass, a convective cell is a region of strong upward air motion; such a warm, buoyant plume of rising air is called an updraft.

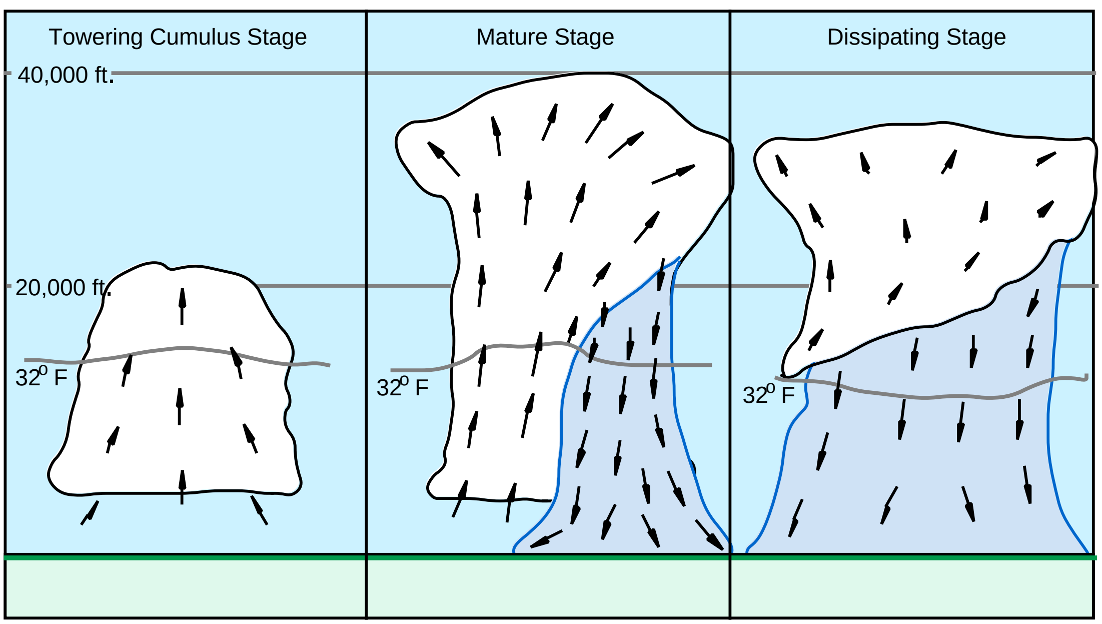

Figure 1. A schematic representation of the three stages of an air-mass thunderstorm.

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A thunderstorm has a three-phase life cycle. The first stage, the towering cumulus stage, consists of an updraft. As the warm air rises, it travels through cooler air above, which causes water vapor to condense into tiny droplets that form a cloud. As the droplets collide, they combine to form larger drops.

When the drops become too large to be held up in the cloud by the updrafts, they fall downward through the cloud and to the ground as rain. As the drops fall downward, they drag cold air with them, causing a downdraft. This is the second or mature stage of the thunderstorm, which consists of both an updraft and a downdraft. As raindrops encounter drier air, evaporation takes place, which cools the air more and enhances the downdraft. The cool air spreads out horizontally as it reaches the ground, producing a cold air outflow or gust front that we generally experience as the cold winds preceding thunderstorms.

The third or dissipating stage of a thunderstorm occurs when the cold downdraft winds begin to erode the warm updraft and eventually cause the storm to weaken and dissipate as the warm, moist air supplied by the updraft is no longer available. Typical thunderstorm cells have life cycles of 55 to 75 minutes and horizontal widths of 3 to 40 square miles.

Several single-cell thunderstorms can cluster together to form a multi-cell thunderstorm. The cold outflows from each cell combine to form a stronger gust front, which in turn can trigger new storms as the rush of cold air pushes warmer air upward, inducing more convection. Multi-cell storms can become severe.

When updrafts are strong enough, hail can form within these storms. As the raindrops encounter freezing temperatures in the tops of the thunderstorm clouds, they freeze. As the small frozen drops move about within the cloud, they gather liquid droplets on their surface. This causes them to become heavy and to begin falling downward through the cloud. The updrafts push the small hailstones upward into the freezing temperatures again, freezing their liquid surfaces and enlarging them. This process is repeated until the hailstone becomes too heavy to be held aloft by the updraft or until the stone is diverted out of the updraft's path and falls to the ground. Taller thunderstorm clouds with the strongest updrafts produce the largest hailstones.

As a thunderstorm cloud grows, it usually reaches the jet stream winds at the top of the troposphere. When this occurs, the top of the thunderstorm cloud gets caught in the winds, blowing the top to the side in what meteorologists call an “anvil."

Supercell thunderstorms, the most dangerous of the convective-type storms, can produce high winds, large hail, and long-lived tornadoes. A supercell storm gains a large scale organization so that it behaves like a single entity rather than a multi-celled storm. The supercell storm's initial development is very similar to that of a single-cell, air-mass thunderstorm, but supercells matures to exhibit a rotating updraft and continuous propagation. Supercell storms can reach maturity within 90 minutes and stay intact for several hours. These were the types of storms that produced the deadly twisters on May 3, 1999, in Oklahoma and Kansas.

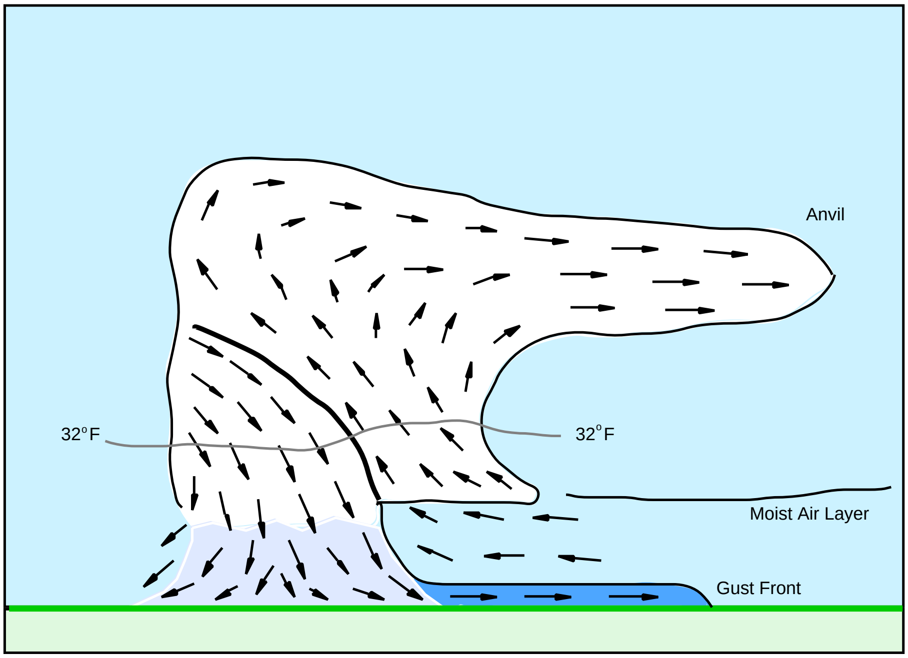

Figure 2. A cross-sectional schematic of a squall line thunderstorm indicating updrafts and downdrafts, gust front, anvil and rain area.

A squall line is any line of thunderstorms, whether associated with a cold frontal passage or not. A squall line can be either a continuous or a broken line of storms that can become severe. Severe storms need to encounter vertical wind shear to be able to sustain a strong, long-lived cir-culation. Unlike the single-cell storm, which eventually dissipates because of the competition of the updrafts and downdrafts, a severe storm's updrafts and downdrafts are farther apart horizontally and work together to feed the storm instead of destroying it.

Mesoscale convective complexes (MCCs) are a type of large, long-lived convective weather system that frequently occurs over the midlatitudes of the United States. MCCs can produce widespread rainfall, locally intense rainfall and flash flooding, tornadoes, hail, strong winds, and intense electrical storms. Almost one of every four MCCs results in injury or death. Some MCCs begin initally as squall lines that gradually acquire MCC characteristics as they persist and grow in size. Many develop in the late afternoon and persist into the night and can be slow-moving, increasing the risk of flooding. MCCs can range in size from 28,000 to 77,000 square miles and can last from 3 to 36 hours.

The MCS Campaign, headed by Peter May of the Australian Bureau of Meteorological Research Centre, will focus on developing methods for determining rain drop size distributions within MCSs by use of vertical wind profilers. Researchers trying to distinguish differences in the physics of various types of MCS storms will also be looking at the precipitation, vertical motions, buoyancy, and electrical characteristics of deep convection. The data collected at the CART site will be compared with data from other midlatitude field projects, as well as data collected in Australia. Researchers can tell a lot about the physics of clouds simply from the rain drop size distribution. The 50-MHz and 915-MHz radar wind profilers at the central site will be used to make these rather unique measurements.